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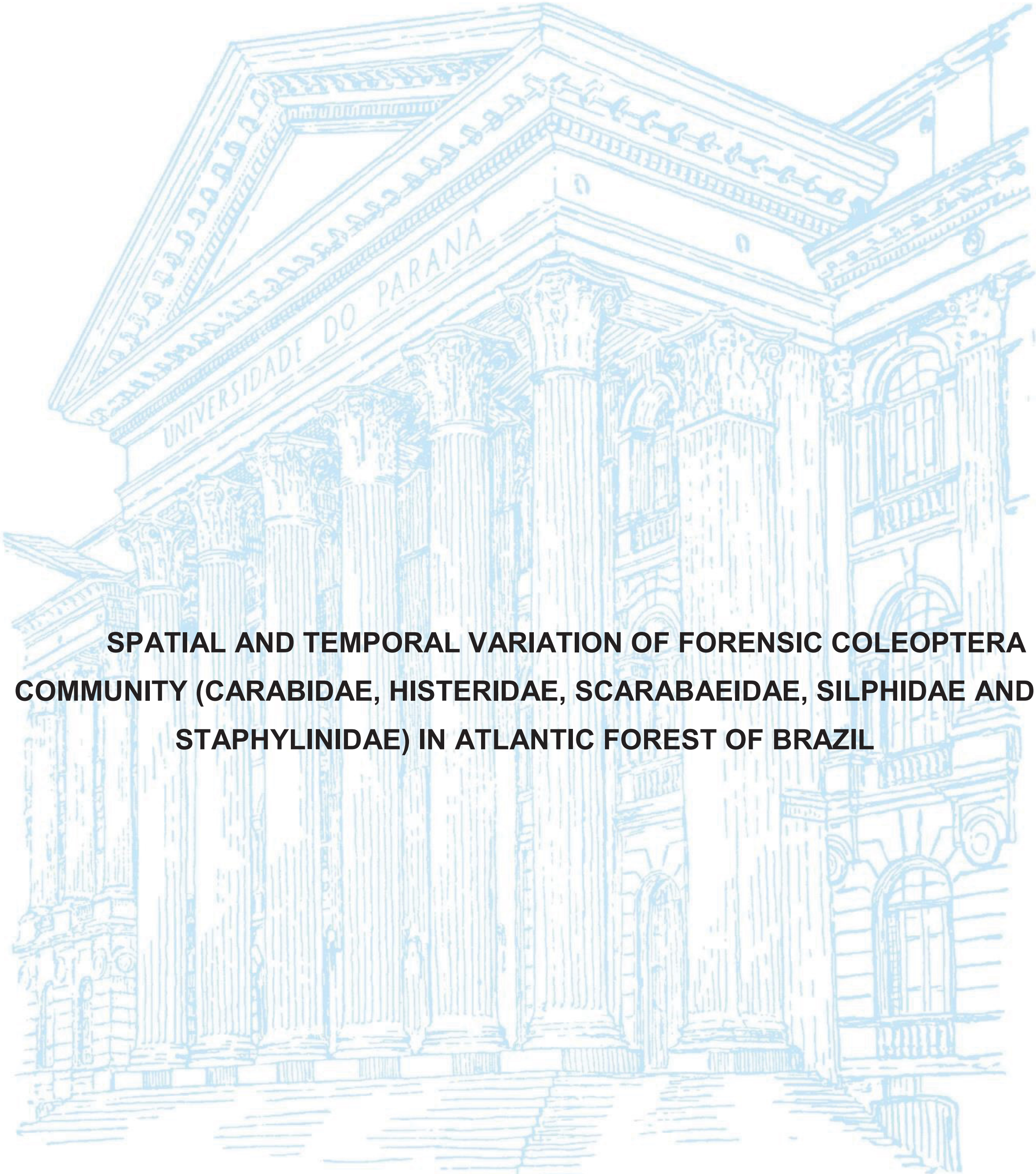

SPATIAL AND TEMPORAL VARIATION OF FORENSIC COLEOPTERA COMMUNITY (CARABIDAE, HISTERIDAE, SCARABAEIDAE, SILPHIDAE AND STAPHYLINIDAE) IN ATLANTIC FOREST OF BRAZIL

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Dissertação apresentada como requisito parcial à obtenção do grau de Mestre em Ciências Biológicas, no Curso de Pós-Graduação em Entomologia, Setor de Zoologia, da Universidade Federal do Paraná.

Orientador: Prof. Dr. Edilson Caron
Co-Orientadora: Prof.ª Dra. Letícia Maria Vieira

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Curitiba, 21 de novembro de 2017.

To my parents and brothers that
taught me the values and always believed
and supported me, my sincere gratitude.
To Eduardo that encouraged me to always
follow my dreams and become a better
human being,my heartfelt thanks.

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Só foi possível chegar aqui, pois vocês estiveram juntos comigo!

I do not know what I may appear to the world, but to myself I seem to have been only like a boy playing on the sea-shore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me.

- "Memoirs of the Life, Writings, and Discoveries of Sir Isaac Newton" (1855) por Sir David Brewster (Volume II. Ch. 27)

RESUMO

O presente estudo visa responder algumas perguntas ecológicas que poderão ser aplicadas à Entomologia Forense. O estudo de cinco famílias de Coleoptera com importância forense, Carabidae, Histeridae, Silphidae, Scarabaeidae e Staphylinidae, em três áreas do bioma de Mata Atlântica gera um arcabouço de dados que vem preencher uma lacuna dos estudos forense no Brasil, à variação espacial e temporal de espécies de interesse forense em um bioma que circunda a maioria das grandes cidades no Brasil. Nas análises foram usados dados de três estudos previamente desenvolvidos em Barbacena, sudeste de Minas Gerais, Curitiba e Palotina, respectivamente leste e oeste do Paraná. Essas localidades foram selecionadas por apresentarem inventários recentes com enfoque forense onde métodos de coleta e duração do experimento foram similares podendo deste modo serem comparados. A partir da resposta obtida pelas análises foi possível determinar que há uma complementariedade de métodos de coleta (quando não utilizados armadilhas) para estudos da fauna forense e também as espécies que possuem maior especificidade com o local de estudo, e também um melhor entendimento do papel desses coleópteros na Entomologia Forense. O Valor de indicação de espécies foi medido atraves do IndVal, sendo as relações de riqueza, abundância e variáveis ambientais calculadas. De acordo com as análises de similaridade de espécies nas três localidades foi possível determinar uma diferença espacial e temporal da comunidade. A família Staphylinidae se sobressaiu demonstrando seu grande potencial de Indicador Forense tanto para os locais de coleta quanto para os métodos, evidenciando a necessidade em ampliar os estudos dessa família em biologia, comportamento e especificidade de hábitat para possíveis usos aplicados. A presença de algumas espécies foram marcadas por variações espaciais e temporais, permitindo uma caracterização baseada na ocorrência de um certo taxa como *Euspilotus azureus* (Sahlberg, 1823), *Oxelytrum discicolle* (Brullé, 1840), *Aleochara (Xenochara)* Mulsant & Rey, 1874, *Aleochara pseudochrysorrhoa* Caron, Mise & Klimaszewski*, 2008; Atheta iheringi* Bernhauer, 1908, and *Belonuchus rufipennis* (Fabricius, 1801), podendo ser utilizadas como marcadores espaciais de ocorrência dentro do polígono formado pelas três cidades amostradas.

Palavras-chave: Entomologia Forense. Valor Indicador Individual.Coleoptera.

ABSTRACT

This study aims to answers ecological questions to be applied in Forensic Science. The study of five families of forensic importance Carabidae, Histeridae, Silphidae, Scarabaeidae and Staphylinidae in three locations of Atlantic Biome could generate knowledge to fill the gap in forensic studies in Brazil, the temporal and spatial variation in three cities placed in a Biome that surround the biggest cities in Brazil. Three studies previously developed in Barbacena Southeast of Minas Gerias, Curitiba west and Palotina east of Paraná. These localities were selected because they conduct the experiment cataloging the fauna and which the collection methods, and duration of the experiment were similar and could be compared, being the temporal and spatial variation pointed for the Bioma of Atlantic Forest where most of the crimes occur. Following the answers obtained from the analysis it was possible to determine the complementarity of the collection method (when no trap are used) for forensic studies, and priorizing the study from the species that are more specific with the place, and having a better understanding with this beetles from Forensic Entomology. The indicator value of each species was measured with IndVal method. The relationship between richness, abundance and environmental variables was calculated. Acoording to the analysis of similarity the composition of the species community in the three localities was different temporal and spatial. The Staphylinidae family stand out as the family with more forensic importance for place of collection and methodology, showing a necessity of increase the studies of this family in biology, behaviour and more habitat specificity for more applied uses. The presence of some species were pointed as markers of spatial and temporal variation, allowing a better characterization based in their occurence of taxa such as *Euspilotus azureus* (Sahlberg, 1823), *Oxelytrum discicolle* (Brullé, 1840), *Aleochara (Xenochara)* Mulsant & Rey, 1874, *Aleochara pseudochrysorrhoa* Caron, Mise & Klimaszewski*, 2008; Atheta iheringi* Bernhauer, 1908, and *Belonuchus rufipennis* (Fabricius, 1801), being used as spatial and temporal markers inside the polygon formed by the three cities.

Key-words: Forensic Entomology. Indicator Value. Coleoptera.

FIGURE LIST

TABLE LIST

LIST OF ABBREVIATIONS

ANOSIM	- Análise de Similaridade
DISTLM	- Distância baseada em modelos lineares
DZUP	- Coleção Entomológica Padre Jesus Santiago Moure
IFET	- Instituto Federal de Educação Ciência e Tecnologia
LACON	- Laboratório de Biologia da Conservação
LIPBio	- Laboratório de Pesquisa da Biodiversidade
PMI	- Intervalo pós morte
SIMEPAR	- Sistema Meteorológico do Paraná
UFMT	- Universidade Federal do Mato Grosso
UFPR	- Universidade Federal do Paraná
UFSJ	- Universidade Federal de São João del Rei

SUMMARY

1 INTRODUCTION

Vertebrate carcasses are colonized by different organisms, specially insects, most of them belong to Coleoptera and Diptera order. It is known that distinctive stages of decaying attracts different insects (Payne,1965). As well, studies related with animal carcass have shown differences in the species composition, and the ecological succession differ according to geographic region and climate. (Smith, 1986; Souza & Linhares, 1997; Oliveira-Costa, 2008; Souza, Kirst, & Krüger, 2008). In the world, most of the studies are focused on the Diptera order, and the Coleoptera are neglect (Almeida & Mise, 2009).

The study of the succession of Coleoptera and Diptera species as well as the time that they live in it, could help to determine in which circumstances the death occurred and estimated the post-mortem interval (PMI) in the scope of Forensic Entomology (Keh, 1985; Catts & Goff, 1992). In this situation, beetles represent the most important entomological evidence when the body or carcass is in an advanced decomposition (Kulshrestha & Satpathy, 2001). Several beetles species are specifically associated with animal remains, often preying other insects species that are using the remains and few are using the remain as a food resource (Rosemary & Bryce, 1995).

According to Slipinski, Leschen & Lawrence (2011) Coleoptera has more than 386.500 described species, being the biggest order of class Insecta, with 40% of the knowledge species. According to Monné & Costa (2017) the Brazilian fauna of Coleoptera has about 32.800 valid species, including 2.500 endemic species.

The decomposition process is a way to cycling nutrients and energy in most ecosystems (Carter, Yellowlees, & Tibbbet, 2007; Barton, Cunninggham, & Manning, 2012), and the fauna associated with carrion can lead to medico-legal evidence when arthropods are collected, leading a better understanding of the ecological process (Byrd & Castner, 2010).

The carrion invertebrate species composition of this community may also vary between habitats, days, region, and season. (Campobasso, Di Vella & Introna, 2001; Gibbs & Stanton, 2001).

The invertebrate community vary among each stage of decomposition based on the alteration of the resource, the interaction with other invertebrates through competition and/ or predatory interactions, and this pattern of this community assembly provides a model for ecological resource (Payne, 1965; VanLaerhoven, 2010).

Species of Carabidae, Scarabaeidae, Silphidae, Staphylinidae and Histeridae can be found in different stages of decomposition because are necrophagous or immature blowfly predators (Jiménez, Quezada, & Padilla, 2013; Bala & Singh, 2015; Souza & dos Santos, 2016; Pérez, Jiménez, & Padilla, 2016). Thus, it is very important for forensic entomologists understand the natural variability in necrophagous or insects that prey in who are feeding on the carcass arthropod community assembly for better understanding and better use of predictions and generalization when using entomological evidence to estimate the PMI (Tomberlin, et al., 2011; Michaud, Schoenly, & Moreau, 2012).

Because the difference of the environmental and biotic conditions vary across real-world, it is likely that spatial variation shapes different patterns according to environmental and biotic factors and can considerably affect the spatial variation of the beetle community (Walter, Johnson, & Haynes, 2016).

The unique climatic conditions of different parts of Brazil could entail in a different species composition, indicating a specificity occurrence. The importance of the five families (Carabidae, Histeridae, Staphylinidae, Scarabaeidae and Silphidae) will be evaluated such as richeness, diversity and composition in three different locations in the brazilian territory. These five families were chosen based on the previous studies that point these families as a good indicator for forensic studies being widely collected in Brazil, with necrophagous or predator feeding habit (Carvalho et al., 2000); Almeida & Mise, 2009; Bortoluzzi, Caron, & Guimarães, 2014; Almeida, Corrêa, & Grossi, 2015). This study aims to integrate the data of these families most collected in forensic studies, being them necrophagous or predator inhabitant of carcasses. It is important to point that Cleridae and Dermestidae are good forensic indicator, but we didn’t find in all the three studies allowing the comparison.

Other families are important as well but since we don’t have any of Dermestidae and Cleridae in one or more sites of collections was not possible to evaluate their importance to this study.

1.1 OBJECTIVES

1.1.1 General objective

The main purpose of this study is to analyse the Coleoptera Community of forensic importance, specifically the families Carabidae, Histeridae, Scarabaeidae, Staphylinidae and Silphidae, surveys carried out in three urban fragments of Atlantic Forest.

1.1.2 Specific objectives

The specific aims of this study are:

a) To detect the differences on the beetle community structure of these localities;
b) Ascertain the effect of the environmental variables and methodology upon the communities;
c) indicator species of method, or season on the three localities.

2 LITERATURE REVIEW

2.1 The history of the Forensic Entomology

The first documented case where forensic entomology was used, dated from the 13th century in China when the investigator and lawyer Sung Tźu, describes a case occurred in a rice field where a man was stabbing and the crime was solved when the investigator, told all the works to lay down their sickles, and blow flies were drew from the invisible traces of blood, and the owner of the sickle confronted and confessing the crime. This first documented case was solved by using insects and it is written in the medico-legal book “The washing away of wrongs” (Benecke, 2001).

In 1831 Doctor Orfilia observing exhumations, states that the maggots present in the body plays important roles to the decomposition of the body (Orfilia & Lesueur, 1831), the first modern case involving forensic entomology was conducted by Doctor Bergeret in France in 1855 when the (Postmortem interval) PMI was given through insects (Bergeret, 1855).

Mégnin (1894) described the fauna associated with dead bodies, and assume the PMI using the cycle of life of mites present in the body.

In the South America the use of insects to solve crimes started when Pêssoa & Lane (1941) presents previous records from necrophilous beetles from museums in Brazil, (Jirón, Vargas, & Vargas-Alvarado, 1982; Jirón & Solano, 1988) add information of flies from Costa Rica.

In Argentina some reports were performed relating the fauna and the stages of decomposition (Mariluis, 1983; Mariluis, Lagar, & Bellegarde, 1989).

The entomological work in Brazil started in 1908 with Oscar Freire showing the results of the insects associated with human body and carcass (Pujol-Luz, Arantes, & Constantino, 2008).

It is important to say that from 1908 to 1940 few studies were conducted in the world because of the war, and regarding the value of the procedure and the non-utilization of the forensic entomology to solve crimes (Pêssoa & Lane, 1941). Between 1940 and 1991, there aren’t published works for Forensic Entomology, but after this obscure situation some research groups appear in São Paulo, Rio de Janeiro, Paraná and Distrito Federal (Souza A. M., 1994; Moura, Carvalho, & Monteiro Filho, 1997; Von Zuben, Stangenhaus, & Godoy, 2000).

Another important fact is that most of studies and researchers in Brazil are focused in Diptera. Coleoptera order are specially pointed when the body is in advanced stages of decomposition (Oliveira-Costa, 2008; Pujol-Luz, Arantes, & Constantino, 2008).

2.2 Coleoptera family in Forensic Entomology

The characterization of the order are elytra, and the chewing mouth parts well developed. They are found in all habitats except the sea and saline ambient and have a wide feeding habit (Marinoni, et al., 2001).

It is expected that beetle communities with forensic significance differ according to the region, included in the following families were; Cleridae, Dermestidae, Histeridae, Scarabaeidae, Silphidae and Staphylinidae (Hart & Whitaker, 2005).

Almeida et al. (2015) updated the number of Coleoptera species with forensic importance in Brazil, to 345 species of 16 families. According to Almeida et al. (2015) the families with the highest number of species recorded are Scarabaeidae (158 species), Staphylinidae (84), Histeridae (36) and Carabidae (12). These families represent about 85% of forensic beetle fauna in Brazil.

According to Vaz-de-Mello (2017) 100 genera are found in Brazil comprising 858 species.

Scarabaeidae beetles play a role in different ecological functions such as saprophagy, coprophagy, and necrophagy in their harvesting for food source. Scarabaeidae were the most captured making up 60.8% of all the gathering with 1.039 organisms in Carvalho & Linhares (2001), and even being a family with coprophagy behavior, they include in their food diet decaying animals. In Mayer & Vasconcelos (2013), they found 889 individuals making up 57.3% of all beetles captured.

Staphylinidae is the most diverse family of animal kingdom, with almost 58.000 described species (Grebennikov & Newton, 2012). It has around 5,000 known species in the Neotropical region (Newton & Thayer, 1992). In the Brazilian fauna, 2,812 species are described in 471 genera and allocated in 16 subfamilies (Newton & Caron, 2017). Commonly known as rove beetles, in general most of them are easy to be distinguished by the short and truncated elytra, exposing the abdominal tergites. They are distributed on all continents except Antarctica, and have very different feeding behavior, with predators, saprophagous, mycophagous or ectoparasitic species (Thayer, 2005).

Moreover, rove beetles are found in a wide range of habitats, being one of the main predators of Diptera maggots (Klimaszewski & Génier, 1987).

Since 1911 with Luderwaldt (1911), until the work done by Almeida, Corrêa, & Grossi (2015), several species of Staphylinidae are found in the studies and comprises 78 morpho species found in Brazilian fauna. In the Brazilian fauna 565 species are found, and 213 endemics, also four subspecies and one endemic subspecies belonging to 170 genera (Newton & Caron, 2017). In Silva & Santos (2012) the Staphylinidae beetle sum 52.5% of the trapping with 124 individuals.

Carabidae are among the three most numerous families of Coleoptera, holding the biggest diversity of species in the Neotropical region, Carabidae is a family with 876 species described for Brazil, and 91 subspecies included in 135 genera (Bulirsch & Anichtchenko, 2017). Carabidae is one of the families that have forensic importance (Almeida & Mise, 2009), with predatory feeding behavior they are collected in forensic studies, allowing ecological comparison with the collected data (Smith, 1986). The beetles from this family have diurnal and nocturnal rhythm, and are a voracious predator of other invertebrates (Lövei & Sunderland, 1996). Mayer & Vasconcelos, (2013) in their studies shown that Carabidae is the third richness family with three species and its presence was observed praying Diptera maggot.

In a recent work developed by Almeida, Corrêa, & Grossi (2015) they listed for Brazil 11 species of Carabidae beetles feeding on human or pig carcass.

The Histeridae family own approximately 3.900 species described to the world (Myers, et al., 2017). Bicho, Leivas, & Degallier (2017), show for Brazil the amount of 491 species, two subspecies included in 125 genera. Histeridae beetle are commonly preying maggots and eggs, particularly Cyclorrapha (Diptera), associated with dung, decaying vegetable matter and carcass (Kovarik & Caterino, 2001). In Carvalho & Linhares (2001) Histeridae was the second most abundant family found, with 352 individuals bringing the total of 20.7% of the coleopterous indicating high importance in forensic studies. 31 species including morpho species were recorded in brazilian forensic research (Almeida, Corrêa, & Grossi, 2015).

Silphidae is a family with about 15 genera and 200 species to the world, appearing in the Neotropical region 9 genera and 175 species. In the Brazilian fauna, this family has four described species, and one endemic species, all belonging from 1 genus (Almeida & Mise, 2009). Most Silphidae are found on carrion, and also feeding on maggots found in the vertebrate carcasses (Almeida, Corrêa, & Grossi, 2015). Almeida & Mise (2009) found five species of Silphidae in their studies and appear in the majority of the forensic beetle studies in Brazil, highlighting their importance for Brazilian studies. The major representants of this family are scavenging, and they feed on the animal carcass, the Silphidae immature feeds directly from the corpse, and the adults prey Diptera eggs and immatures (Mise, Almeida, & Moura, 2007).

2.3 Ecological succession in carcasses

The species of insects associated with carrion, vary according to the region and the variables on it, and a database have to be developed for each site to use forensic entomology as tool of ivestigation (Gail & VanLaerhoven, 1996).

The succession is a continuos process, and the insects don't appear and dissapear causing an abrupt change, but they came and go doing some pattern that could be recognized as waves of colonization. Calliphoridae, commonly known as blow flies are the first one that appears in the succession (fresh stage), and lay eggs around the wounds or orifices on the carcass, ants are also found on this first stage (Byrd & Castner, 2010). After few days (bloated stage) adult flies are found and larval blow flies would be also present. At this stage when larvae are present some beetles start to appear to prey eggs and larvae. Beetles from Staphylinidae, and Cleridae, and Carabidae, and Silphidae families are colleccted since this stage. On the advanced stage other waves of insects start to appear such Scarabaeidae, Histeridae, Silphidae, preying Diptera eggs and larvae or using the deceased body to eat. When the body starts to dry, Dermestidae beetles starts to use the last remains of flesh, and bones, and hair or fiber decomposing it (Almeida, Corrêa, & Grossi, 2015; Bala & Singh, 2015).

The necrophagous insect fauna are the most important decompositors in the terrestrial ambient, and can feed from a carcass before a vertebrates or microorganism (fungi and bacteria) feed on them (Carter, Yellowlees, & Tibbett, 2007). In fact they are the first ones to appear on the crime scene regarding the highly specialized sensorial organs (Nuorteva, 1977).

In the fauna found on a crime scene there are an enormous diversity of taxa, such as decompositors, and saprophytes, and reducers based on the manner that they uses the resource and can be classified in the following ecological categories (Norris, 1965): scavenger (will use the body to develop or feed), predator and parasite of scavenger species, omnivorous and accidental, that uses the resource as a extension of their habitat.

According to Catts & Goff (1992) to use the lower limit (PMI) it is necessary to know the life cycle of the insects associated with the body such as abiotic factors (temperature, relative humidity, altitude and latitude). Consequently the larval density, preying and competition also could change the colonization and the insects that will be present on the body (Von Zuben, Stangenhaus, & Godoy, 2000).

The taxonomic identification is the primordial process for Forensic Entomology and regardless the amount of taxa present in our country is not a simple work.

According to studies developed Moura, Carvalho, & Monteiro Filho (1997), Carvalho, et al. (2000), some species have a life cycle to an specific place and because of this specificity it is necessary to map and study the forensic insects in their area of occurrence, once the abiotic factors influence the community in that place.

2.4 Ecological indicators

Lindenmayer, Margules, & Botkin (2000) defined seven types of indicator species: (1) species that indicates the presence of other species, (2) keystone species whose presence or loss changes the ecosystem, (3) species that indicates human-created abiotic conditions, such as, air and water pollution, (4) dominant species that provide the much of their biomass or number of individuals in a specific area, (5) species that indicate particular environmental conditions such as certain rocky types and soil, (6) species that are sensitive to environmental changes (bio-indicators) and (7) management indicator species that reflects the effects of a disturbance regime or the efficacy of particular efforts to mitigate disturbance.

Studies that use beetles as bioindicators are focused on the Scarabaeidae, Carabidae (Cicindelinae) and Staphylinidae including lots of species. These taxa are used as environmental indicator when indicator to indicate degradation or environmental restoration; ecological when a specie or group of species indicates the quality of a habitat, or biodiversity when indicates the biodiversity in general (Bohac, 1999; Rainio & Niemelã, 2003; Durães, Martins, & Vaz-de-Mello, 2005; Marinoni & Ganho, 2006).

Carabidae are being used as bioindicator once they are highly ecological fidelity, and have a good relationship with the environment, highly taxonomic diversity, and are easy to capture (Brown Junior, 1996), and there are species affected when some modification occurs or environmental fragmentation (Didham, 1998).

The Staphylinidae family are broadly distributed in all semi-natural and man-made habitats making staphylinids potential bioindicators, but they are not used as much as ground beetles due the difficult on their taxonomy (Bohac, 1999). Their classification is based on their feeding habit and is the basis for use them on bioindication. The majority of Staphylinidae beetles feed on Arthropoda soil (predator), or organic substances, some are specialized on pollen feeding and are known as trophic specialists (Bohac, 1999).

Staphylinidae can be used as bioindicators of the environmental health and particularly of human influence on ecosystems, and can be collected by pitfall trapping or by soil quadrant samples. Thus, Staphylinidae have good bioindicator features thanks to their ecological specialization, in some cases they are more suitable and sensitive bioindicators than Carabidae beetles, but their importance for biomonitoring is limited based on the difficult of identification (Bohac, 1999).

Silphidae is a family with scavenger and saprophytes feed habits, in forest ecosystems beetles that are involved with the nutrient cycling can also be use as bioindicator because their specificity to their habit (Kim, 1993).

Scarabaeidae beetles are detritivores and promote the removal and re-entry of organic matter on the ecosystem, the Scarabaeidae beetles play other roles in forest fragments when they feed on excrements and vertebrate carcasses that are quickly influence by human colonization (Thomanzini & Thomanzini, 2000). This family is ideal to use as biodiversity monitoring because they can use a wide range of resources including carcasses and feces of other animals, in addition the Scarabaeidae community can indicate and influence the restoration efforts (Nichols, et al., 2008). The distribution of Scarabaeidae beetles can be influenced by the vegetative cover, fragmentation, and are important to determine composition, abundance and richness of their community (Bala & Singh, 2015).

3 MATERIAL AND METHODS

3.1 DATA COLLECTION

The beetles of the five families were selected from three studies previsously developed in Barbacena, Southeast of Minas Gerias (Gomes & Vieira 2012), Curitiba (Mise et al. 2007) and Palotina (Bortoluzzi et al. 2014), respectively west and east of Paraná. This localities were selected because they conduct the experiment cataloging the fauna and which the collection methods, and duration of the experiment were similar and could be compared. All the differences among the data collection are on APPENDIX B. The beetles collected in all three surveys were reidentified and the morphotypes were compared by the specialists Edilson Caron (Staphylinidae), Fernando Leivas (Histeridae), Fernando Vaz-de-Mello (Scarabeidae), and (Carabidae) Leticia Vieira. All the material are placed in DZUP.

3.1.1 Curitiba – Paraná

Experiment was carried out in a forest clearing located in Curitiba- PR (25°26'43.33"S 49°13'58.67"W) in a mixed ombrophilous forest remain in the Polytechnic Center in the Federal University of Parana (UFPR) with approximately 49.000 m^2, Biological Science Sector (figure 1). The data collection was performed from September 23th, 2005 until September 22th, 2006. In each season, one *Sus scrofa* Linnaeus, 1758 carcass weighting 15 kilograms, slaughtered with a heart injury. The carcass was placed in a cage to avoid the interference of predators. A superior lid and a manual in the bottom were placed in the trap to collect the invertebrates underneath the carcass. The cage was installed in clearing place (without tree) and covered with a modified Shannon trap measuring 1.5 m base diameter X 1.5 meters high, capturing the flying insects. The data collection was incremented by five pitfall traps were placed around the cage. The same collector realized all the collection in order to minimize the error by data collection. Adults of Coleoptera collected were sacrificed, transferred for entomological blankets, and posterior pinned and labeled. The identification was made with a key or by specialists, after all the material was placed in the Entomological Collection Pe. J. S. Moure. The weather data condition was obtained from (SIMEPAR), locate in the Polytechnic Center.

3.1.2 Palotina – Paraná

The experiment developed in a forest fragment (24°17’35” S; 53°50’32” W) attached to Palotina *campus* – UFPR with Semideciduous Broadleaved Forest formation in secondary forest cover (figure 2) with approximately 50.000 m^2. The collection was realized during June 21st, 2011 and May 03rd, 2012, at the beginning of each season one domestic pig *Sus scrofa* Linnaeus, 1758 with average weight of 12 kilograms was euthanized with chemical method according the procedures described by Ethics Committee, Bioethics and Animal Welfare (CEBEA n° 36/2010, UFPR, *campus* Palotina). After this procedure, a metal cage was placed over the carcass avoiding other animals to harm the experiment. The insects were collected in all these methodologies, modified Shannon with 1.8m base diameter and 2.0 meters high, to capture the Coleoptera that fly away from the carcass, being changed every day, four Pitfall traps were installed around the cage to capture the Coleoptera that comes to feed or pray in the carcass by soil changed every four days, and manual collection every two days with 15 minutes duration. The beetles collected were placed in alcohol 70° GL and addressed to Integrated Laboratory of Biodiversity Research (LIPBio-UFPR, *campus* Palotina), all the beetles were pinned, morphotyped and placed into the Scientific Collection, attached to the LIPBio. All the weather data were obtained from SIMEPAR, located in Curitiba.

3.1.3 Barbacena – Minas Gerais

Experiment developed in Barbacena, Minas Gerais (21°14'8.21"S; 43°45'42.52"W) in the forested area of Federal Institute of Minas Gerais Southeast, *campus* Barbacena, composed by native forest characterized as Semideciduous Broadleaved forest with approximately 177.000 m^2 (figure3). The collections were performed from January 27th, 2012 until December 8th, 2012 with no collection during the winter because some vertebrate ruin the experiment. Every season two pigs with 15 kilograms were euthanized and placed into two metal cages, with a lateral opening and movable manual under to collect beetles that were there. One modified Shannon trap was placed over the cage with the dimensions 100X60X50 centimeters for flying beetles. Five Pitfall traps were placed around the cage. The active collection was realized every day with clamps. The Shannon was changed every day, and the Pitfalls were changed every 7 days. The abiotic variables were collected with a Thermo-Hygrometer, as well as the rectal temperature realized with a digital thermometer. The adult beetles were euthanized in alcohol 70° GL, placed into entomological blankets. All adults were pinned morphotyped, identified with a key or by specialists and placed into the Scientific Collections from UFSJ, Laboratory of Biology Conservation (LACON), LIPBio (UFPR – *campus* Palotina) and Beetles belonging to Scarabaeidae family (UFMT).

3.2 DATA ANALYSIS

Accumulation species curves in all site collection were performed through EstimateS program to compare the biodiversity richness found in the three sites of collection (Colwell, 2013).

The Venn diagram was made showing the similarities of the species in the three collection sites showing the beetles that occur only in one site and those that occur in more than one collection site, showing the beta diversity (β).

Distance-based linear models (DistLM) (Legendre & Anderson, 1999) was performed to ordinate the community, based in a Bray-Curtis similarity matrix to access the statistical significance between the community structure and the predictive analysis (temperature, relative humidity, season, collection methods), analyzing and modeling the relation between the community data and predictive variables at the same time. It is important to mention that DistLM analyses quantitative and categoric variables, and can be used to modeling data that uses a mix of categoric predictive and continuous variables. This analysis was ran in the PRIMER program (Anderson, Gorley, & Clarke, 2008).

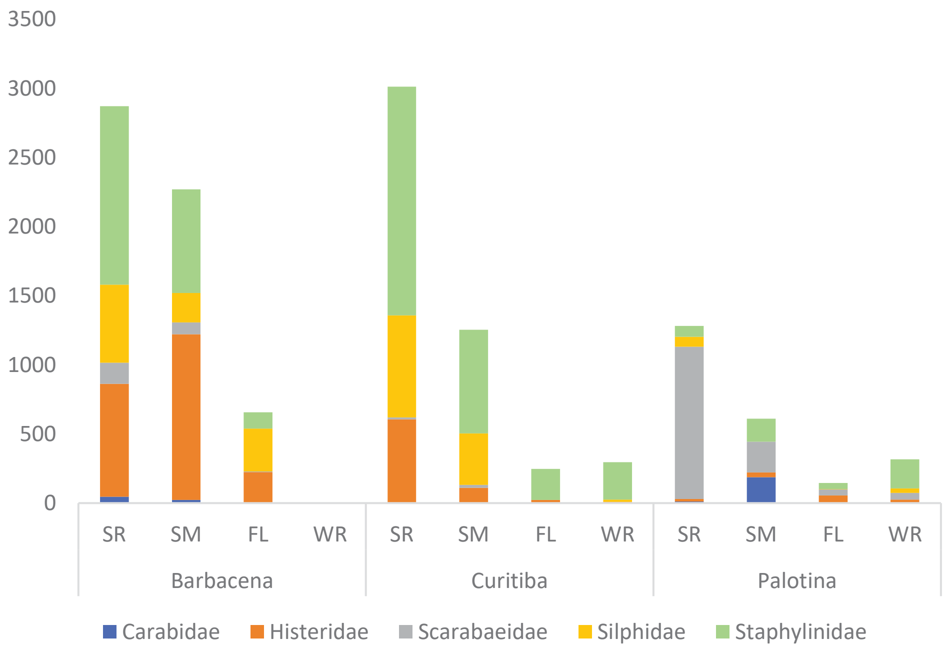
To determine the species association of a specific location Indicator Value (IndVal) was calculated the value the rate of each specie. This rate measures the rank, the specificity and the fidelity of one specie in a related place (Dufrene & Legendre, 1997), and the software PC-Ord will compute it (McCune & Mefford, 2011).

4 RESULTS

4.1 Community analysis

There was a total of 12,631 beetles of forensic importance belonging from 5 families captured in Summer, Fall and Spring in Barbacena (5,796), Curitiba (4,481) (Summer, Fall, Spring and Winter) and Palotina (2,354) (Summer, Fall, Spring and Winter) (APPENDIX A) (Figure1).

The family most collected in Barbacena was Histeridae with 17 species (2.239 individuals) followed by Staphylinidae with 38 spp. (2.158), Silphidae 1 sp. (1.084), Scarabaeidae 26 spp. (244), and Carabidae 9 spp. (69). In Curitiba we found Staphylinidae with 22 spp. (2.902), Silphidae 1 sp. (1.129), Histeridae 3 spp. (741), Carabidae 4 spp. (6) Scarabaeidae 4spp. (33). Palotina show another pattern being Scarabaeidae the most collected with 12 spp. (1.419), then Staphylinidae 23 spp. (496), Carabidae 4 spp. (199), Histeridae 6 spp. (134) and Silphidae 1 spp. (106). showing fidelity with other works in the world and Brazil such as (Carvalho et al., 2000); (Hart & Whitaker, 2005); (Almeida & Mise, 2009); (Silva & Santos, 2012); (Almeida, Corrêa, & Grossi, 2015).



SR – Spring; SM – Summer; FL – Fall; WR - Winter

FIGURE 1 – Coleoptera species with forensic importance, collected in Barbacena (a), Curitiba (b), Palotina (c) by seasons.

4.2 Temporal variation

Barbacena (2a) was the location with more species than Curitiba (2b) and Palotina (2c). In Barbacena (2a) more species/individuals were observed during Spring and Summer. In Curitiba (2b) it was observed the same pattern, although in Palotina (2c), the Summer season had more species/individuals but in other season do not present the same pattern.

The richness of species does not differ between the stations in Palotina during the four seasons, but Barbacena (figure 2) have considerably more species richness than the three collection sites with more species during summer and spring. Only for this result were used all the data collected in Curitiba and Palotina.

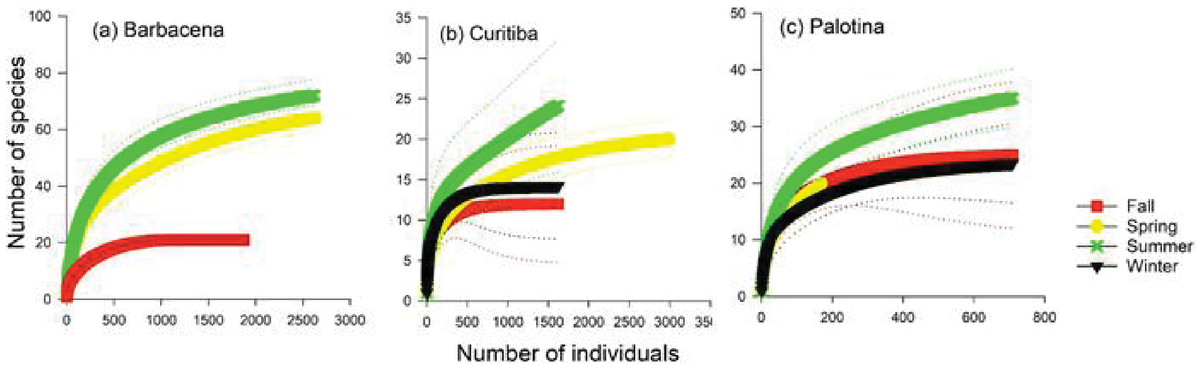


FIGURE 2 – Accumulation curve of Coleoptera species with forensic importance, collected in Barbacena (a), Curitiba (b), Palotina (c) in four different seasons. Dotted lines indicate the confidence interval (95%)

4.3 Collection methods

Pitfall collected more species/individuals in the three-collection sites however in Barbacena (3a) manual collected the same number. In Curitiba (3b) Shannon collected the fewer proportion of species/individuals, as well in Palotina (3c). No data from Winter were taken into account on this result.

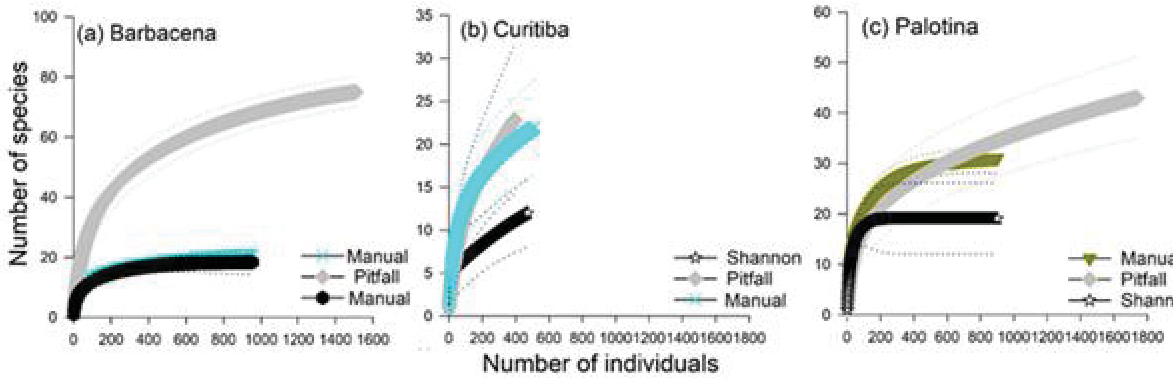


FIGURE 3 – Accumulation curve of Coleoptera species, collected in Barbacena (a), Curitiba (b), Palotina (c) in three different collection methods. Dotted lines indicate the confidence interval (95%)

4.4 Spatial variation

Considering the spatial β (figure 4) diversity in the three sites of collection Barbacena has more than 55.6% of the exclusive species, Palotina (17.4%) and Curitiba (13.2%), the spatial changes in species composition regarding these three sites of collection, this pattern indicate that the physio geographic pattern influence the structure of beetles.

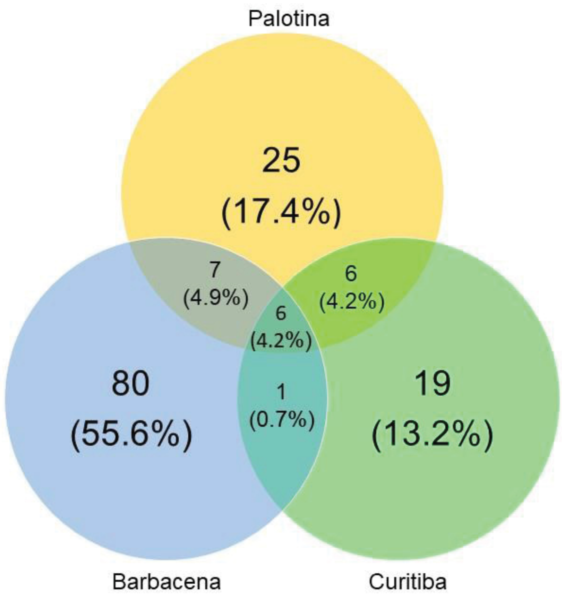


FIGURE 4 – Venn diagram of spatial variation in beetle species

The faunistic composition varies in number and species in all three sites of collection and only six species appear in all of them (figure 4) were collected from carcasses placed in Barbacena, Curitiba and Palotina namely *Euspilotus azureus*, *Oxelytrum discicolle*, *Aleochara (Xenochara)*, *Aleochara pseudochrysorrhoa; Atheta iheringi*, and *Belonuchus rufipennis*.

When we take into account the same 6 we could observe a pattern with *Euspilotus azureus*, *Oxelytrum discicolle*, *Atheta iheringi* and *Belonuchus rufipennis* species occurring in Summer, Spring, while *Aleochara* (*Xenochara*) sp., *Aleochara pseudochrysorrhoa* occurring for Spring, Fall and Summer. None of these species are seasonal.

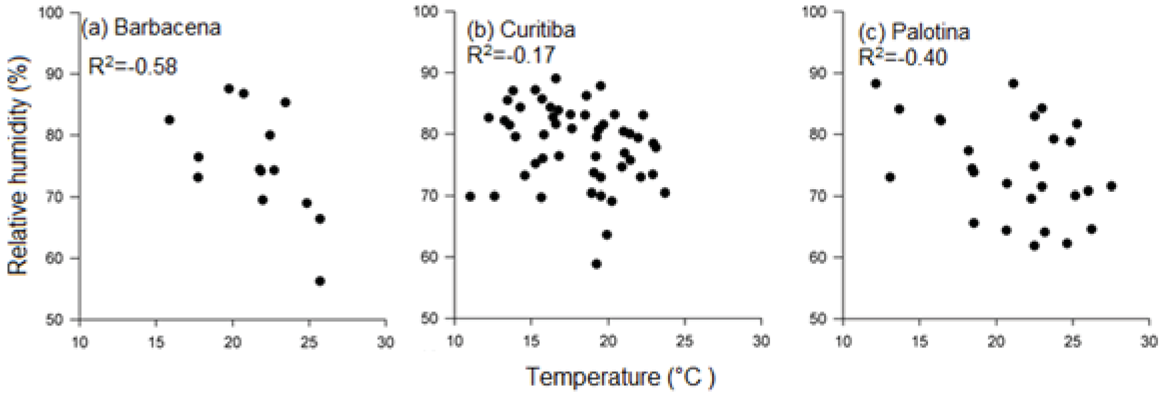


FIGURE 5 – Draftsman plot of the environmental variables (temperature and relative humidity) collected during the experiment in the three collection sites.

The draftsman plot (figure 5) shows that UR and Temperature are not strongly correlated, but since they are the ones equal for the three sites they were used.

The marginal test (table 1) confirms that for Barbacena, Curitiba and Palotina all the variables are significant with ($P<0.001$) indicating the community structure is explained by the environmental variables, the collection method, season and relative humidity.

TABLE 1 – Marginal test for Barbacena, Curitiba and Palotina

Group	SS(trace)	Pseudo-F	P
MET	1,21E+08	14.113	0.001
TEMP	41984	12.649	0.001
EST	22437	3.242	0.001
UR	20456	5.927	0.001

MET: Collection method; TEMP: Temperature; EST: Season; UR: Relative Humidity

The sequential test (table 2) provides a summary of the relationships between the variables and the biotic data after sequentially fitting the variables. The results of this test show that collectively the environmental variables can explain 29,45% of the biological variation composition, and therefore 70,55% still remain unexplained. However, when examined collectively, all variables are shown to significantly ($P\leq 0.05$) contribute to the variability in the biological data.

TABLE 2 – Sequential test for Barbacena, Curitiba and Palotina

SEQUENTIAL TESTS						
Group	R^2	SS(trace)	Pseudo-F	P	Prop.	Cumul.
+MET	0.20822	1,21E+08	14.113	0.001	0.20822	0.20822
+TEMP	0.2311	13336	47.599	0.001	2,29E+02	0.2311
+EST	0.28374	30694	58.066	0.001	5,26E+02	0.28374
+UR	0.29459	6324.5	24.143	0.01	1,08E+02	0.29459

MET: Collection method; TEMP: Temperature; EST: Season; UR: Relative Humidity

Marginal test (table 3) ratify for Barbacena collection methods, season and relative humidity are significant with (P≤ 0.05) confirming the relationship between the environmental variables and the biotic similarity matrix individually.

TABLE 3 – Marginal test for Barbacena

MARGINAL TESTS			
Group	SS(trace)	Pseudo-F	P
MET	28764	69.028	0.001
EST	20552	44.199	0.001
UR	6614.9	24.899	0.01
TEM	5073.2	18.784	0.071

MET: Collection method; TEMP: Temperature; EST: Season; UR: Relative Humidity

The sequential test (table 4) results from this test show that collectively the environmental variables can explain 47.58% of the biological variation composition, and therefore 52,42% still remains unexplained. Although, when examined collectively, only two variables are shown to significantly (P≤ 0.05) contribute to the variability in the biological data.

TABLE 4 – Sequential test for Barbacena

SEQUENTIAL TESTS						
Group	R^2	SS(trace)	Pseudo-F	P	Prop.	Cumul.
+MET	0.28879	28764	69.028	0.001	0.28879	0.28879
+EST	0.47583	18630	57.093	0.001	0.18704	0.47583
+UR	0.48873	1285	0.78224	0.675	1,29E+02	0.48873
+TEM	0.50577	1697.4	10.345	0.417	1,70E+02	0.50577

MET: Collection method; TEMP: Temperature; EST: Season; UR: Relative Humidity

Collection methods, season, relative humidity and temperature are significant with (P≤ 0.05) for Curitiba, (table 5) confirming the relationship between the environmental variables and the biotic similarity matrix individually.

TABLE 5 – Marginal test for Curitiba

MARGINAL TESTS				
Group	SS(trace)	Pseudo-F	P	Prop.
EST	24208	55.832	0.001	0.14988
MET	26881	19.367	0.001	0.16643
TEM	5180.8	32.146	0.015	3,21E+02
UR	6443.2	40.304	0.009	3,99E+02

MET: Collection method; TEMP: Temperature; EST: Season; UR: Relative Humidity

Moreover, the sequential test (table 6) results from this test show that collectively the environmental variables can explain 46,38% of the biological variation composition, and therefore 53.62% still remains unexplained. However, when examined collectively, only two variables are shown to significantly (P≤ 0.05) contribute to the variability in the biological data.

TABLE 6 – Sequential test for Curitiba

SEQUENTIAL TESTS						
Group	R^2	SS(trace)	Pseudo-F	P	Prop.	Cumul.
+EST	0.14988	24208	55.832	0.001	0.14988	0.14988
+MET	0.3141	26523	22.505	0.001	0.16422	0.3141
+TEM	0.31987	932.24	0.78926	0.525	5,77E+00	0.31987
+UR	0.33345	2192.4	18.735	0.101	1,36E+02	0.33345

Palotina in the marginal test (table 7) confirms that season, collection methods, and temperature are significant with (P≤ 0.05) confirming the relationship between the environmental variables and the biotic similarity matrix individually.

TABLE 7 – Marginal test for Palotina

MARGINAL TESTS				
Group	SS (trace)	Pseudo-F	P	Prop.
EST	32569	33.273	0.001	0.16369
MET	19555	28.337	0.001	9,83E+02
TEMP	10557	29.697	0.001	5,31E+02
UR	5716.4	15.677	0.073	2,87E+01

The sequential test (table 8) results from this test show that collectively the environmental variables can explain 42,79% of the biological variation composition, and therefore 57.21% still remains unexplained. However, when examined collectively, only two variables are shown to significantly (P≤ 0.05) contribute to the variability in the biological data.

TABLE 8 – Sequential test for Palotina

SEQUENTIAL TESTS						
Group	R^2	SS (trace)	Pseudo-F	P	Prop.	Cumul.
+EST	0.16369	32569	33.273	0.001	0.16369	0.16369
+MET	0.26431	20022	33.511	0.001	0.10063	0.26431
+TEMP	0.2855	4215.2	14.232	0.142	2,12E+02	0.2855
+UR	0.29805	2497.9	0.84058	0.607	1,26E+02	0.29805

There are more indicator species in Barbacena, according to the IndVal results, (table 9) from all three collection sites being *Agerodes* sp.1 (spring) and *Philonthus* sp.4 (summer) as an important indicator species, for Curitiba *Oxelytrum discicolle* (spring) and *Aleochara* (Xenochara) (spring) and for Palotina *Canthon septemmaculatus* (spring).

TABLE 9 – indicator value for Coleoptera community by locality and season

BAR- Barbacena; CUR- Curitiba; PAL- Palotina; TG – Trophic group; IV – Indicator Value

Site	Season	Family (TG)	Species	IV	p
BAR	Spring	Staphylinidae	*Agerodes* sp.1	89.9	<0.001
	Summer	(Predator)	*Aleochara bonariensis* Lynch, 1884	32.4	0.037
	Fall		*Aleocharinae* sp.5	26.7	0.032
	Summer		*Atheta iheringi* Bernhauer, 1908	33.3	0.016
	Spring		*Philonthus* sp.3	59.5	0.003
	Summer		*Philonthus* sp.4	63.0	0.001
	Summer		*Platydracus* sp.1	41.7	0.043
	Spring		*Platydracus* sp.2	56.5	<0.001
	Summer		*Xenopygus analis* (Erichson,1840)	46.7	0.002
	Spring	Scarabaeidae	*Deltochilium rubripenne* Gory,1831	45.0	0.010
	Summer	(Scavenger)	*Dichotomius* sp.2	32.4	0.037
	Summer	Histeridae	*Hister cavifrons* Marseul, 1854	50.5	0.016
	Summer	(Predator)	*Phelister brevistrius* Marseul,1853	43.5	0.008
	Spring		*Phelister* sp.3	33.3	0.010
CUR	Spring	Staphylinidae	*Aleochara* (*Xenochara*) Mulsant & Rey 1874	61.6	<0.001
	Spring		*Aleochara pseudochrysorroa* Caron, Mise & Klimaszeswki, 2008	26.7	0.005
	Spring		*Atheta iheringi* Bernhauer, 1908	45.5	0.005
	Summer		*Philonthus* sp.3	31.2	0.005
	Spring		*Anotylus* sp.2	25.6	0.001
	Spring		*Belonuchus rufipennis*	14.4	0.044
	Summer		Anotylus sp.1	13.4	0.043
	Spring	Silphidae (Scavenger)	*Oxelytrum discicolle* Brullé, 1840	72.3	<0.001
	Spring	Histeridae	*Euspilotus azureus* (Sahlberg, 1823)	35.5	0.006
PAL	Spring	Scarabaeidae	*Eurysternus parallelus* Castelnau, 1840	33.0	0.014
	Spring		*Canthon septemmaculatus* Latreille,1811	62.7	<0.001
	Spring	Silphidae	*Oxelytrum discicolle* Brullé, 1840	37.1	0.006
	Spring	Carabidae	Carabidae sp.3	22.2	0.023
	Summer	(Predator)	Cicindelinae sp.1	35.7	0.002

According to the IndVal, Barbacena presents more indicator species (table 10) than the other collection sites, being *Euspilotus azureus* (manual), *Aleocharinae* sp.2 (pitfall) and *Oligotergus* sp.1 (manual) as an important indicator species, for Curitiba

Atheta iheringi (manual) and *Philonthus* sp.4 (Shannon) and for Palotina *Canthidium* aff*. dispar* (pitfall)*.*

TABLE 10 – Indicator VALUE for Coleoptera community in three collection methods, Pitfall, Manual, and Shannon, by locality

BAR- Barbacena; CUR- Curitiba; PAL- Palotina; TG – Trophic group; IV – Indicator Value

Site	Methods	Family (TG)	Species	IV	p
BAR	Pitfall	Staphylinidae	*Aleocharinae* sp.1	58.3	<0.001
	Pitfall	(Predator)	*Aleocharinae* sp.2	66.7	<0.001
	Pitfall		*Aleocharinae* sp.5	33.3	0.009
	Manual		*Atheta iheringi* Bernhauer, 1908	41.7	0.002
	Pitfall		*Belonuchus rufipennis*	61.2	<0.001
	Manual		*Bolitogyrus* sp.1	58.3	<0.001
	Manual		*Lissohypnus* sp.1	50.0	<0.001
	Manual		*Oligotergus* sp.1	65.5	<0.001
	Pitfall		*Oxytelinae* sp.1	25.0	0.049
	Pitfall		*Oxytelinae* sp.2	41.7	0.002
	Pitfall		*Paederinae* sp.1	41.7	0.003
	Pitfall		*Platydracus* sp.1	47.2	0.016
	Pitfall	Scarabaeidae	*Dichotomius* sp.2	47.1	0.003
	Pitfall	(Scavenger)	*Dichotomius* sp.3	41.7	0.003
	Manual	Silphidae (Scavenger)	*Oxelytrum discicolle* Brullé, 1840	55.0	0.016
	Manual	Histeridae	*Euspilotus azureus* (Sahlberg, 1823)	78.7	<0.001
	Manual	(Predator)	*Euspilotus excavata* Arraigada, 2012	39.2	0.010
	Manual		*Hister cavifrons* Marseul, 1854	60.2	0.001
	Pitfall		*Phelister* sp.2	33.3	0.014
	Pitfall	Carabidae	Carabidae sp.1	25.0	0.043
	Pitfall	(Predator)	*Pterostichini*	17.6	<0.001
CUR	Manual	Staphylinidae	*Aleochara pseudochrysorroa* Caron, Mise & Klimaszeswski, 2008	36.0	<0.002
	Manual		*Atheta iheringi* Bernhauer, 1908	63.3	0.002
	Shannon		*Philonthus* sp.3	39.5	<0.001
	Shannon		*Philonthus* sp.4	53.1	<0.001
	Manual		*Belonuchus rufipennis*	19.6	0.001
	Manual	Histeridae	*Euspilotus azureus* (Sahlberg, 1823)	54.7	<0.001
PAL	Shannon	Staphylinidae	*Aleochara bonariensis* Lynch, 1844	27.9	0.028
	Pitfall	Scarabaeidae	*Canthidium* **aff**. *dispar* (Harold, 1867)	67.1	<0.001
	Pitfall		*Deltochilum morbillosum* Burmeister, 1848	32.1	0.033
	Pitfall		*Canthon (Goniocanthon) smaragdulus* (Fabricius, 1781)	43.3	0.012
	Pitfall		*Canthon septemmaculatus* Latreille, 1811	46.0	0.018
	Manual	Silphidae	*Oxelytrum discicolle* Brullé, 1840	36.0	0.010
	Pitfall	Carabidae	Cicindelinae sp.1	22.7	0.023

5 DISCUSSION

The analysis of the coleopterofauna in different regions of Atlantic Rainforest Biome allowed to observe that the richness is higher during the summer and spring, when insects are more active because the climate conditions and they could breed and generate offsprings (Hernández & Vaz-de-Mello, 2009) (Lopes et al., 2011). It is entirely reasonable that in the Neotropical region, especially in Brazil where the seasons are not very distinctive. The same result was found in (Moura, Carvalho, & Monteiro Filho,1997).

The pitfall trapping had high efficiency in all three collection sites non-generalization of this type of catching, capturing all of the beetles in activity near the carcass. This method is also efficient to collect those beetles that are pursuing food resource or preying other beetle larvae or Diptera that are surrounding the carcass. It is a methodology that enrich the richness and the number of individuals and most of the Coleoptera captured show forensic importance as in (Lopes de Carvalho & Linhares, 2001); (Almeida & Mise, 2009); (Almeida, Corrêa, & Grossi, 2015).

Spatial variation in species distributions also affect beetle response to habitat, and responses to environmental variables, as well as species differences in habitat and feeding specialization, and intraspecific aggregation.

Corroborating to Prado & Castro (2013) the composition of Coleoptera community changed along with the carcass decomposition and the decomposition can explain the variability. However, other factors (e.g., the vegetation structure of the Biome Atlantic) may influence on the community composition of Coleoptera. It is consistent to say that the presence of this could indicate at least the position of the carcass in this Biome.

Low β diversity indicates that the 3 sites of collection are non-complementary. For this reason, it is important to study several sites to understand the patterns of beetles spatial region distribution as the basis for the forensic tool. In biological terms, these differences could be explained by the species replacement due the spatial distribution along the Atlantic Rainforest Domain. No further studies for forensic purpose were done using this diversity measurement by comparing forensic beetles fauna through the Atlantic Rainforest (Whittaker, 1972); (Harrison, Ross, & Lawton, 1992); (Marinoni & Ganho, 2006).

The lowest richness and diversity were recorded during fall and winter for Curitiba and Palotina and fall to Barbacena, expressing that the largest number of species are restricted to months with favorable conditions, such as the warmer and rainier seasons of spring and summer. This positive correlation between heat and precipitations is a factor that contribute to abundance, diversity and richness of beetle community (Matuszewski & Szafalowicz 2013); (Damborsky et al. 2015).

Although it is clear that the community changes among Barbacena, Curitiba and Palotina and it cannot be assumed that all species collected are associated with the carcass. Once we evaluated the rate of pitfall catch increasing the richness of the beetles in the study significantly, it is suggested that some of the species collected by this methodology would be only accidentals. It is not possible to determine if they would reach or they would be coming, only by observing and analyzing the fauna sampled by this methodology.

Other methods such as above temperature of the carcass, structure of the vegetation or the use of more sample units (carcass) would result in better results about the community composition. Unfortunately, all the works done in Forensic Entomology in Brazil used few pigs per season, which could be solved by using more pigs for each season. The few number of samples (carcass) used is a combined effect of several reasons, as increasing the field effort, time to process the biological material and identification and available financial resources to conduct the project.

The sophisticated analysis through the multivariate space is not sufficient to capture the variations on the community and it is not correlated with temperature and relative humidity, to express the pattern of the community, needing to add more variables to capture it.

It is clear that the community changes between Barbacena, Curitiba and Palotina and they are quite different, but cannot assume that all species collected are associated with the carcass, once evaluated the rate of pitfall catch increasing significantly the richness of the beetles in the study, but I have to consider that some of the species collected by this methodology is nonspecific and in this study we cannot able to tell exactly if they are belonging from the carcass, or if they are captured only for being near the experiment.

When take in account the season Staphylinidae family represents the one that point out with more Indicator Value being in Barbacena *Agerodes* sp.1 (89.9), and *Philontus* sp.4 (63.0), for Curitiba we have *Aleochara* (Xenochara) (61.6). The abundance and the high Indicator Value number can show that Staphylinidae for being present in different season and use the resource preying Diptera eggs and pupae are a good organism for forensic indicator purpose also found in other studies (Souza & Linhares, 1997); (Almeida & Mise, 2009); (Almeida, Corrêa, & Grossi, 2015), indicating a better understanding of the ecology and more taxonomists to determine species. In Palotina none of Indicators are from Staphylinidae family.

Oxelytrum discicolle (72.3) in Curitiba and 37.1 in Palotina also show the importance of the Silphidae family for forensic studies, but in Barbacena as in (Rosa, et al., 2011) the abundance was high in the beginning lasting the presence but reducing the number of individuals until the end of the decay and this could be explained by the high rate of adults collect during the beginning of the decaying overrating the capture on the initial decay process.

Only in Palotina *Canthon septemmaculatus* (Scarabaeidae) with 62.7 indicator value, indicating also the importance of Scarabaeidae family, and more studies have to be done since many of beetles from this family are not predator and they come to the carcass following the strong odor coming from the carcass (Marinoni et al., 2001).

The importance of predators to the forensics studies are reinforced when more than 90% of indicator species are from this trophic guild well represented by Staphylinidae, *Aleocharinae* sp.2 (66.7), *Oligotergus* sp.1 (65.5) and Belonuchus *rufipennis*, Histeridae, *Euspilotus azureus* (78.7), *Hister cavifrons* (60.2) in Barbacena, mostly collected by manual, indicating that they are using the resource, and *Atheta iheringi* e *Philontus* sp.4 for Curitiba being *Atheta iheringi* also collected on manual, and Palotina with exclusively Scarabaeidae family with high indicator value *Canthidium* aff. *dispar* (67.1) and *Canthon septemmaculatus* (46.0) indicates that these organisms are coming to find food resource since proposed (Lovejoy et al., 1986; Dekeirsschieter et al. 2013).

5.1 FINAL CONSIDERATIONS

The insects could give us valuable, meaningful answers regarding investigations about causes or circumstances of the death, however for this happened more studies of biology, ecology and more taxonomic work should be developed in the species that would be more significance for Forensic Entomology. When we unify all this data from a country or a specific place it is possible to evaluate the decomposition process and how these insects in especially Coleoptera are distributed spatially and temporal allowing to have a better understanding on death crimes.

The studies point out a distinct Coleoptera community for the places studied, as well as varying patterns of carrion decomposition. Although the composition of the carrion Coleoptera community present in each study location could give an overview of what we have to look out.

For a better progress of this Science in Brazil considering the territorial extension it is necessary that more works are published and the researches create a web of knowledge, priority must be given on applied and basic science regardless know the fauna from different habitats and with different anthropization levels. More data should be released showing indicator species for forensic purpose.

This study can contribute to better understanding of indicator species in three different sites allowing to monitor and start a distribution map of species with high fidelity to the season, local, and methodology.

The family the most point out as a good forensic indicator for Atlantic forest are the representative of Staphylinidae family being found in most of these studies presented and moreover have high value in all three surveys carried.

The results from this dissertation have allowed significant contributions to be made to the field of forensic entomology, as known that insect colonization and succession patterns maybe influenced by temperature, vegetation, season and geographic locations. It is necessary to develop a baseline data set for entomology applications.

In this study, contributions were made to further both season, regional and collection methods from areas previously examined but not placed together.

Overall, this study produced several significant contributions to the field of forensic entomology. Together, the expanded the interpretation on forensic entomology and increases the role of a forensic entomologist in a criminal investigation.

SELF-CRITIQUE

Only adult stages were included in this study, because was difficult to collect and identify the immature stages. However, it is also important to study the immature stages of beetles that could give a valuable information. Another point to take in account is that at least 30 carcasses of pigs have to be placed in each site per season avoiding the replication of data. The data from Winter in Barbacena was nor collected once had some interference of vertebrate in the experiment, therefore all the data from Winter to Curitiba and Palotina was not taken into account in most of the analysis.

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APPENDIX A - TABLE WITH ALL SPECIES AND NUMBER OF OCCURRENCE

		Barbacena				Curitiba				Palotina				Total
Family	Specie	SR	SM	FL	WR	SR	SM	FL	WR	SR	SM	FL	WR	
Carabidae	*Athrostictus speciosus* (Dejean,1829)	0	3	0	_	0	0	0	0	0	0	0	0	3
	Calleida sp.	1	0	0	_	0	0	0	0	0	0	0	0	1
	Carabidae sp.1	0	0	0	_	1	1	0	0	0	1	0	0	3
	Carabidae sp.2	0	0	0	_	1	0	0	1	0	2	0	0	4
	Carabidae sp.3	0	0	0	_	0	1	0	0	12	0	0	0	13
	Carabidae sp.4	0	0	0	_	0	0	0	1	0	0	0	0	1
	Cicindelinae sp.1	0	0	0	_	0	0	0	0	0	184	0	0	184
	Gallerita sp.	11	8	0	_	0	0	0	0	0	0	0	0	19
	Harpalini sp.	4	2	0	_	0	0	0	0	0	0	0	0	6
	Iresia sp.	0	1	0	_	0	0	0	0	0	0	0	0	1
	Lebiini sp.	2	0	2	_	0	0	0	0	0	0	0	0	4
	Megacephala brasiliensis (Kirby,1818)	0	1	0	_	0	0	0	0	0	0	0	0	1
	Odontocheila brasiliensis (Djean, 1825)	1	0	0	_	0	0	0	0	0	0	0	0	1
	Pterostichini	26	7	0	_	0	0	0	0	0	0	0	0	33
Histeridae	*Euspilotus azureus* (Sahlberg, 1823)	626	824	217	_	586	94	20	6	1	4	0	0	2378
	Euspilotus excavata Arriagada, 2012	2	23	2	_	0	0	0	0	0	0	0	0	27
	Hister cavifrons Marseul, 1854	69	279	2	_	0	0	0	0	2	11	0	11	374
	Hister sp.	0	0	0	_	14	13	2	0	0	0	0	0	29
	Hololepta sp.1	0	1	0	_	0	0	0	0	12	15	54	14	96
	Omalodes omega (Kirby,1818)	1	5	0	_	0	0	0	0	0	0	0	0	6
	Omalodes sp.1	0	1	0	_	0	0	0	0	0	0	0	0	1
	Omalodes sp.2	0	3	0	_	0	0	0	0	0	0	0	0	3
	Operclipygus sp.1	29	0	0	_	0	0	0	0	0	0	0	0	29
	Phelister brevistrius Marseul, 1854	6	33	0	_	0	0	0	0	0	0	0	0	39
	Phelister sp.	0	0	0	_	0	0	0	0	0	5	0	0	5
	Phelister sp.1	0	10	0	_	0	0	0	0	0	0	0	0	10
	Phelister sp.2	63	6	0	_	0	0	0	0	0	0	0	0	69
	Phelister sp.3	19	0	0	_	0	0	0	0	0	0	0	0	19
	Phelister sp.4	0	4	0	_	0	0	0	0	0	0	0	0	4
	Phelister sp.5	1	0	0	_	0	0	0	0	0	0	0	0	1
	Phelister sp.6	0	2	0	_	0	0	0	0	0	0	0	0	2
	Phelister sp.7	0	6	1	_	0	0	0	0	0	0	0	0	7
	Phelister sp.9	0	0	0	_	5	1	0	0	0	0	0	0	6
	Scapomegus aurifer Marseul, 1887	2	2	0	_	0	0	0	0	1	0	0	0	5
	Scapomegus gibbus Marseul, 1855	0	0	0	_	0	0	0	0	1	1	1	1	4

Scarabaeidae	*Aphodiinae* sp.1	0	0	0	_	6	8	0	0	0	0	0	0	14
	Ataenius picinus Harold, 1868	0	0	0	_	0	1	0	0	0	0	0	0	1
	Canthidium aff. *dispar*	0	0	0	_	0	0	0	0	20	18	14	27	79
	Canthidium barbacenicum Preudhomme de Borre, 1886	0	3	0	_	0	0	0	0	0	0	0	0	3
	Canthidium breve (Germar, 1824)	3	0	1	_	0	0	0	0	0	0	0	0	4
	Canthidium korschefskyi Balthasar, 1939	0	1	0	_	0	0	0	0	0	0	0	0	1
	Canthidium lucidum Harold, 1867	0	5	0	_	0	0	0	0	0	0	0	0	5
	Canthidium sp.1	1	3	0	_	0	0	0	0	0	0	0	0	4
	Canthidium sp.2	2	0	0	_	0	0	0	0	0	0	0	0	2
	Canthidium trinodosum Boheman, 1858	2	0	0	_	0	0	0	0	0	0	0	0	2
	Canthon	0	1	0	_	0	0	0	0	0	0	0	0	1
	Canthon (Goniocanthon) smaragdulus (Fabricius, 1781)	0	0	0	_	0	0	0	0	26	52	15	1	94
	Canthon chalybaeus Blanchard, 1843	0	0	0	_	0	0	0	0	14	5	1	2	22
	Canthon septemmaculatus (Latraille,1811)	0	0	0	_	0	0	0	0	153	49	4	7	213
	Chalcocropis hesperus (Olivier, 1789)	1	0	1	_	0	0	0	0	0	0	0	0	2
	Coilodes gibbus (Perty, 1830)	0	0	0	_	0	0	0	0	787	65	0	2	854
	Coprophanaeus saphirinus (Sturm, 1826)	5	2	0	_	0	0	0	0	0	0	0	0	7
	Coprophaneus cyanescens (d'Olsoufieff, 1924)	0	0	0	_	0	0	0	0	0	0	1	0	1
	Deltochilum brasiliensis (Castelnau, 1840)	1	0	0	_	0	0	0	0	0	0	0	0	1
	Deltochilum morbillosum Burmeister, 1848	0	0	0	_	0	0	0	0	53	10	3	2	68
	Deltochilum rubripenne (Gory, 1831)	50	7	0	_	0	0	0	0	0	0	0	0	57
	Dichotomius bicuspis (German,1824)	3	1	0	_	0	0	0	0	0	0	0	0	4
	Dichotomius bos (Blanch,1843)	3	0	0	_	0	0	0	0	0	0	0	0	3
	Dichotomius louzaidai Nunes, Carvalho & Vaz-de-Mello, 2015	47	27	2	_	0	0	0	0	0	0	0	0	76
	Dichotomius mormon (Ljungh,1799)	22	0	0	_	0	0	0	0	0	0	0	0	22
	Dichotomius muticus (Luderwaldt, 1922)	1	1	0	_	0	0	0	0	0	0	0	0	2
	Dichotomius saphirinus	1	0	0	_	0	0	0	0	0	0	0	0	1
	Dichotomius sp.	0	0	0	_	6	11	0	0	0	0	0	0	17
	Dichotomius sp.1	0	5	0	_	0	0	0	0	0	0	0	0	5
	Dichotomius sp.2	3	16	0	_	0	0	0	0	0	0	0	0	19
	Dichotomius sp.3	2	10	0	_	0	0	0	0	0	0	0	0	12
	Eurysternus cyanencens Balthasar,1939	0	4	0	_	0	0	0	0	0	0	0	0	4
	Eurysternus parallelus Castelnau, 1840	2	1	0	_	0	0	0	0	43	21	2	0	69
	Onthophagus sp.	0	0	0	_	0	1	0	0	0	0	0	0	1
	Onthophagus sp.1	1	0	0	_	0	0	0	0	0	0	0	0	1
	Onthophagus tristis Harold,1873	2	0	0	_	0	0	0	0	0	0	0	0	2
	Phanaeus dejeani Harold,1873	1	0	0	_	0	0	0	0	0	0	0	0	1
	Scarabaeidae sp.11	0	0	0	_	0	0	0	0	5	0	0	8	13
	Scarabaeidae sp.13	0	0	0	_	0	0	0	0	1	0	0	0	1

	Scarabaeidae sp.4	0	0	0	_	0	0	0	0	1	1	5	0	7
	Scarabaeidae sp.9	0	0	0	_	0	0	0	0	0	1	0	0	1
Silphidae	*Oxelytrum discicolle* (Brullé, 1840)	563	211	310	_	738	374	0	17	72	0	2	32	2319
Staphylinidae	*Agerodes* sp.1	914	23	0	_	0	0	0	0	0	0	0	0	937
	Aleochara (Xenochara) Mulsant & Rey, 1874	5	7	0	_	30	17	6	0	0	4	4	0	73
	Aleochara bonariensis Lynch, 1884	0	32	5	_	0	0	0	2	0	5	8	8	60
	Aleochara pseudochrysorrhoa Caron, Mise & Klimaszewski, 2008	26	45	17	_	1213	444	154	71	5	11	3	18	2007
	Aleocharinae sp.1	40	43	1	_	0	0	0	0	0	0	0	0	84
	Aleocharinae sp.2	23	21	32	_	0	0	0	0	0	0	0	0	76
	Aleocharinae sp.3	2	0	0	_	0	0	0	0	0	0	0	0	2
	Aleocharinae sp.4	0	0	1	_	0	0	0	0	0	0	0	0	1
	Aleocharinae sp.5	0	10	0	_	0	0	0	0	0	0	0	0	10
	Aleocharinae sp.6	0	1	0	_	0	0	0	0	0	0	0	0	1
	Aleocharinae sp.7	0	12	0	_	0	0	0	0	0	0	0	0	12
	Anotylus sp.1	0	0	0	_	0	10	0	3	0	0	0	0	13
	Anotylus sp.2	0	0	0	_	19	5	0	2	0	0	0	0	26
	Atheta iheringi Bernhauer, 1908	0	46	0	_	317	125	42	153	1	41	11	42	778
	Belonuchus rufipennis (Fabricius, 1801)	19	64	49	_	22	12	0	0	13	42	7	73	301
	Belonuchus sp.2	0	2	0	_	0	0	0	0	0	0	0	0	2
	Belonuchus sp.3	0	2	0	_	0	0	0	0	0	0	0	0	2
	Biocrypta sp.	0	0	0	_	0	0	0	0	1	0	0	0	1
	Bolitogyrus sp.	0	0	0	_	0	0	0	0	0	1	1	3	5
	Bolitogyrus sp.1	14	6	0	_	0	0	0	0	0	0	0	0	20
	Cilea sp.	0	0	0	_	0	2	0	0	0	0	0	0	2
	Creophilus maxillosus (Linnaeus,1758)	3	8	4	_	0	0	0	0	2	2	0	0	19
	Echiaster sp.	0	0	0	_	1	5	0	0	0	0	0	0	6
	Eulissus sp.	0	0	0	_	0	1	0	0	0	0	0	0	1
	Eulissus sp.1	2	2	0	_	0	0	0	0	0	0	0	0	4
	Gastricus sp.1	0	2	0	_	0	0	0	0	0	0	0	0	2
	Heterothops sp.1	0	1	0	_	0	0	0	0	0	0	0	0	1
	Heterothops sp.	0	0	0	_	2	0	0	0	0	0	0	0	2
	Isanopus sp.1	2	0	0	_	0	0	0	0	0	0	0	0	2
	Leistotrophus versicolor (Gravenhorst, 1806)	0	0	0	_	0	0	0	0	1	0	0	0	1
	Leucotyreus sp.	0	0	0	_	2	0	0	0	0	0	0	0	2
	Lissohypnus sp.	0	0	0	_	0	1	0	0	0	1	0	1	3
	Lissohypnus sp.1	6	11	0	_	0	0	0	0	0	0	0	0	17
	Nacaeus sp.	0	0	0	_	4	0	0	0	0	0	0	0	4
	Neobisnius sp.1	3	25	2	_	0	0	0	0	0	0	0	0	30
	Oligotergus sp.1	48	15	0	_	0	0	0	0	3	6	1	42	115

Oligotergus sp.2	3	3	0	_	0	0	0	0	0	0	0	0	6
Oligotergus sp.4	8	4	0	_	0	0	0	0	0	0	0	0	12
Osorius sp.	0	0	0	_	0	0	0	0	2	2	0	0	4
Oxypodini sp.	0	0	0	_	2	10	0	0	0	0	0	0	12
Oxytelinae sp.1	3	32	0	_	0	0	0	0	0	0	0	0	35
Oxytelinae sp.3	0	1	0	_	0	0	0	0	0	0	0	0	1
Paederinae sp.1	19	3	0	_	0	0	0	0	0	0	0	2	24
Paederinae sp.2	2	0	0	_	0	0	0	0	0	0	0	0	2
Paederini sp.1	0	0	0	_	0	0	0	0	0	2	0	0	2
Pederinae sp.1	0	6	0	_	0	0	0	0	0	0	0	0	6
Paedorominus sp.	0	0	0	_	0	0	0	0	0	0	0	1	1
Phanolinus sp.	0	0	0	_	0	0	0	0	1	0	0	0	1
Philonthus sp.1	0	0	0	_	5	2	0	0	3	17	7	18	52
Philonthus sp.2	0	0	0	_	4	2	0	0	10	0	0	0	16
Philonthus sp.3	18	69	6	_	0	0	0	20	0	0	0	0	113
Philonthus sp.4	60	162	2	_	29	61	14	20	0	0	0	0	348
Philonthus sp.5	0	0	0	_	0	1	1	0	0	0	0	0	2
Philonthus sp.6	0	0	0	_	4	48	5	0	0	0	0	0	57
Philontina sp.	0	0	0	_	0	2	0	0	0	0	0	0	2
Platydracus sp.	0	0	0	_	0	0	0	1	0	1	0	0	2
Platydracus sp.1	20	35	1	_	0	0	0	0	0	0	0	0	56
Platydracus sp.2	49	2	0	_	0	0	0	0	0	0	0	0	51
Platydracus sp.3	2	0	0	_	0	0	0	0	0	0	0	0	2
Quedius sp.	0	0	0	_	2	1	3	0	0	0	0	0	6
Quedius sp.1	0	6	0	_	0	0	0	0	0	0	0	0	6
Renda sp.1	0	1	0	_	0	0	0	0	0	0	0	0	1
Tachyporinae sp.1	0	0	0	_	0	0	0	0	1	0	0	0	1
Triacus dilatus Nordmann,1837	0	3	0	_	0	0	0	0	0	0	0	0	3
Uroxys sp.	0	0	0	_	0	0	0	0	1	2	0	0	3
Xanthopygus sp.	0	0	0	_	0	0	0	0	4	0	0	1	5
Xenopygus analis (Erichson, 1840)	0	45	0	_	0	0	0	0	29	29	2	0	105

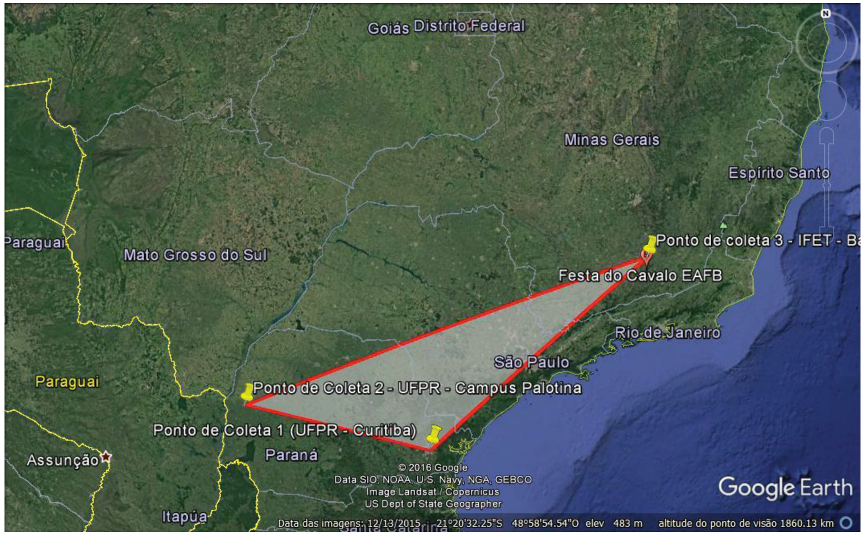
SR= Spring; SM= Summer; FL= Fall; WR= Winter

APPENDIX B – COLLECTION POINTS

(1a)

(1b)

(1c)



(2)

COLLECTION POINTS: (1a) POLYTECHNIC CENTER – UFPR –CURITIBA – BRAZIL; (1b) PALOTINA – UFPR – PALOTINA – PARANA – BRAZIL (1c) BARBACENA – IFET –MINAS GERAIS– BRAZIL (2) POLYGON FORMED BY THE THREE COLLETION POINTS SOURCE: Google Earth, 2017

APPENDIX C – DATA COLLECTION

	Curitiba	Barbacena	Palotina
Geographic coordinates	25°26'43.33"S 49°13'58.67"W	21°14'8.21"S; 43°45'42.52"W	24°17’35” S; 53°50’32” W
Florestal formation	mixed ombrophilous forest	Semideciduous Broadleaved forest	Semideciduous Broadleaved Forest
Area of the fragment	≅ 49.000 m^2	≅177.000 m^2	≅ 50.000 m^2
Year of collection	Sept 2005 - Sept 2006	Jan 2012 - Dec 2012	June 2011 - May 2012
Seasons	Summer/ Fall/ Winter/ Spring	Summer/ Fall/ Spring	Summer/ Fall/ Winter/ Spring
Type of carcass	Pig	Pig	Pig
Weight of the carcass	≅ 15 kilograms	≅ 15 kilograms	≅ 12 kilograms
Type of death	Heart injury	Heart injury	Chemical method
Methodology	Manual/ Shannon/ Pitfall	Shannon/ Pitfall/ Manual/	Shannon/ Pitfall/ Manual
Abiotic conditions	Temperature/ Relative Humidity	Temperature/ Relative Humidity/ Rectal temperature	Temperature/ Relative Humidity